# HIGHWAY RESEARCH REPORT

# A PULSE TYPE INDUCTIVE LOOP SENSOR

69-18

## INTERIM REPORT

STATE OF CALIFORNIA

BUSINESS & TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 636393

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STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, *Governor*

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

5900 FOLSOM BLVD., SACRAMENTO 95819

April 1969

Interim Report
M & R No. 636393
C-1-9

Mr. J. A. Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a report titled:

A PULSE TYPE INDUCTIVE LOOP SENSOR

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Very truly yours,

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Materials and Research Engineer

ABSTRACT

REFERENCE: Stoffers, Karl and Kubel, L. G., "A Pulse Type Inductive Loop Sensor", State of California, Department of Public Works, Division of Highways, Materials and Research Department. Research Report 636393, April 1969.

ABSTRACT: A new sensor for inductive loop vehicle detection has been tested. It produces an output pulse of constant length (50-100 ms) and is actuated by the rate of change of the loop inductance. The new sensor differs from the customary presence sensor in that it loses fewer counts due to coincident actuations when used with multiple loops. This pulse sensor exhibits more than one pulse for extremely slow vehicles (speeds below 12 mph if a 6 x 6 foot loop is used).

KEY WORDS: Vehicle detecting equipment, loops/electrical, vehicles, traffic actuated detectors, traffic counters.

## ACKNOWLEDGEMENTS

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The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the Bureau of Public Roads.

# I. INTRODUCTION

Loop sensors use the change of inductance in a loop of wire resulting from the presence of vehicle iron parts to detect the passage of vehicles. At present, they are often used with several loops; for example, one loop per traffic lane connected to one sensor unit. The contacts of the output relay close for as long a period as a vehicle is present in one (or more than one) of the loops. If traffic is dense and speeds are low, a noticeable number of actuations are lost due to the overlapping presence of vehicles in more than one of the different loops.

This report describes the investigation of a new sensor with a 50-100 ms output pulse which promises to reduce the number of actuations lost because of coincidence.

This investigation was conducted as a part of Materials and Research Department Research Project 636393 to develop test methods and specifications for highway traffic control devices.

## II. CONCLUSION AND RECOMMENDATION

In the normal operating range the new sensor seems to be a more accurate detector of traffic volume and a more sensitive detector of headway between vehicles. This unit does not give a 100% accurate count of vehicles when operated from a multiple loop configuration, but it will give an improved count over conventional units. For best accuracy, application of this sensor should be restricted to installations in which the loops do not experience an excessive amount of low speed traffic.

Four pulse type loop detectors have been installed at intersections in District 07 in the Los Angeles area. The operational effectiveness of these units is being observed by District 07 personnel and, if favorable, will be the basis for a future revision in the specifications for traffic sensor units.

## III. PRINCIPLE OF OPERATION

In a sensor unit, a distortion voltage is generated which is proportional to the change in inductance caused by a vehicle traversing the loop. Typical signals resulting from passenger cars and trucks are shown in Figure 1.

If a conventional presence sensor is employed, the output relay contacts will close for the full duration of the distortion signal, which means a closure time that depends on length and speed of the vehicle.

In the new sensor, the output contacts are activated by a one shot multivibrator which delivers a pulse of 50 milliseconds duration. The one shot is triggered by the front slope of the distortion signal. Due to a blocking circuit in the sensor, the time between two successive output pulses cannot be less than 300 milliseconds.

Ordinarily, a vehicle entering a loop (6 feet x 6 feet) needs a time interval of less than 300 milliseconds to cause peak inductance change and this will generate one pulse in the new sensor. If another vehicle in a different lane enters another loop in the same sensor system before the first vehicle has left its loop, the two distortions are superimposed as shown in Figure 2. If the resultant combined distortion is still increasing after 300 milliseconds or more following the initial first vehicle entry, a new output pulse will be triggered indicating the presence of a second vehicle. However, more than one pulse will also be generated by single vehicles proceeding at speeds below 12 mph since the distortion signal at this slow vehicle speed will still be increasing for more than 300 milliseconds after the car enters a loop. If the vehicle is traveling slow enough, many pulses will result from the one vehicle as shown in Figure 4.

## IV. OPERATING CHARACTERISTICS

The extent to which overlapping distortion signals from two loops on the same sensor system can be separated is illustrated in Figure 3. Two ordinary passenger vehicles with equal speed are assumed. The presence mode sensor will produce two pulses if car "B" has left Loop 1 before car "A" begins to enter Loop 2. Assuming the length of the vehicles to be 16 feet and the loop width to be 6 feet, the minimum spacing between the two cars to produce independent signals is therefore about 22 feet (line A - A).

If the new pulse type sensor is to register two pulses, car "A" cannot complete its entry into Loop 2 in less than 300 milliseconds after the first pulse for car "B". The minimum spacing represented by line B - - - - B is then also dependent on speed of vehicles. In the speed range from 12 mph to 62 mph, this new sensor will detect many coincident arrivals on multiple loop systems which the current presence mode sensor cannot detect. This is illustrated by the triangular area in Figure 3 which is bounded by lines A - A, B - B, and C - C. The low speed region in which a single car will produce more than one pulse with the pulse type sensor underlies line C - - - - C in Figure 3.

Gap sensing circuits in controllers start timing at the end of the detector actuation. If a presence mode sensor is used, the gap begins at the rear of the first car and terminates at the front of the second car. The new pulse type sensor unit, in contrast, will be triggered by the front of both cars and the controller will sense a slightly larger gap for the same situation.

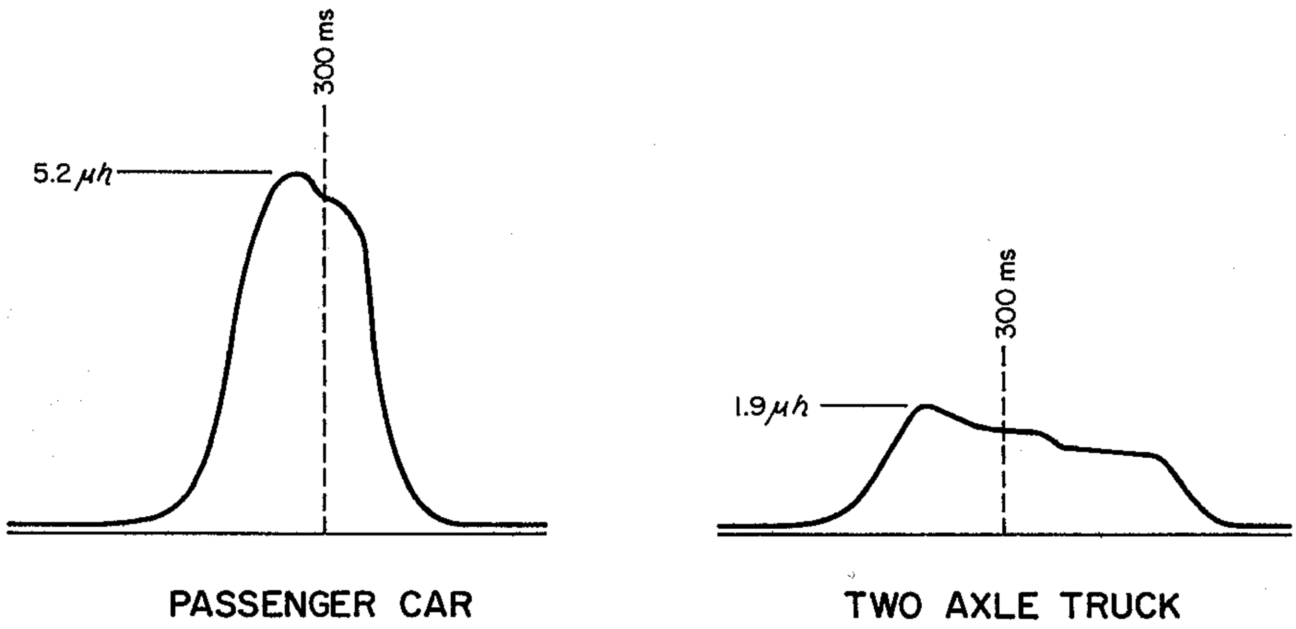



Figure 1

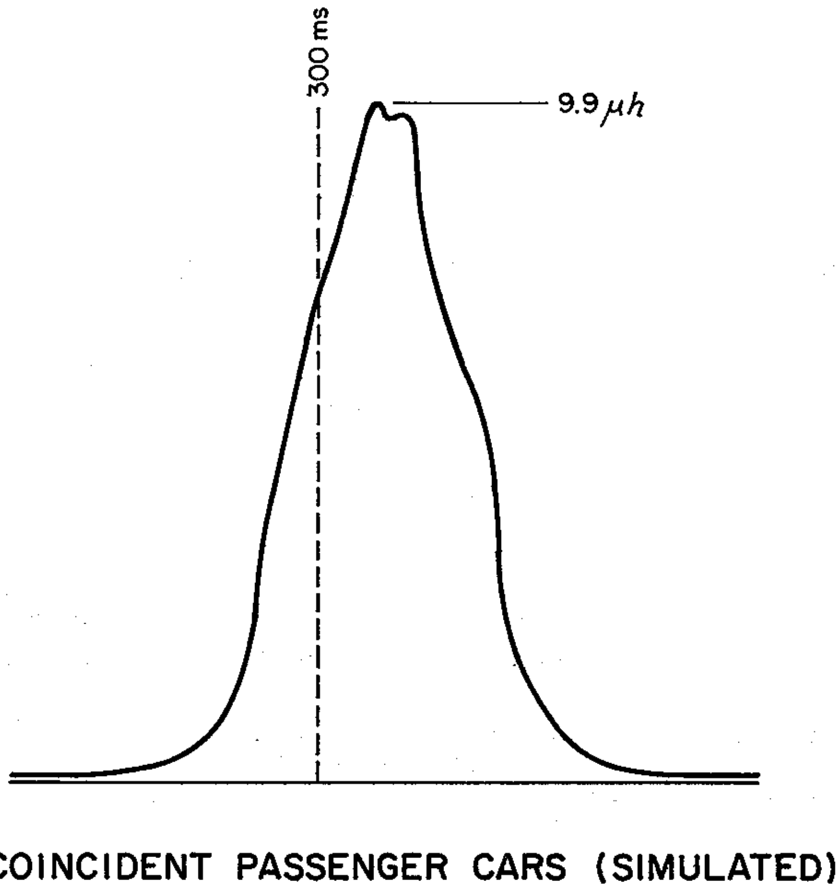
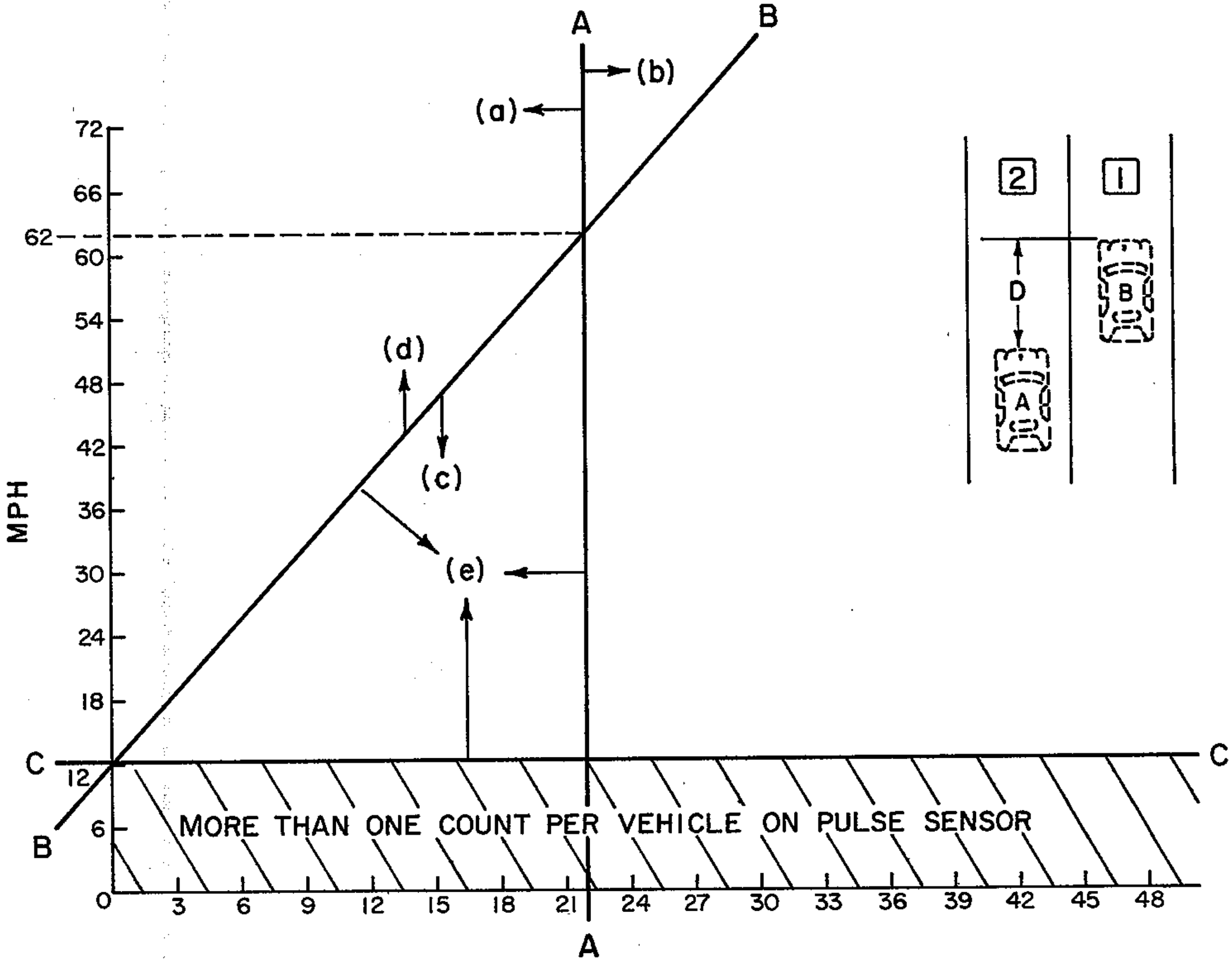


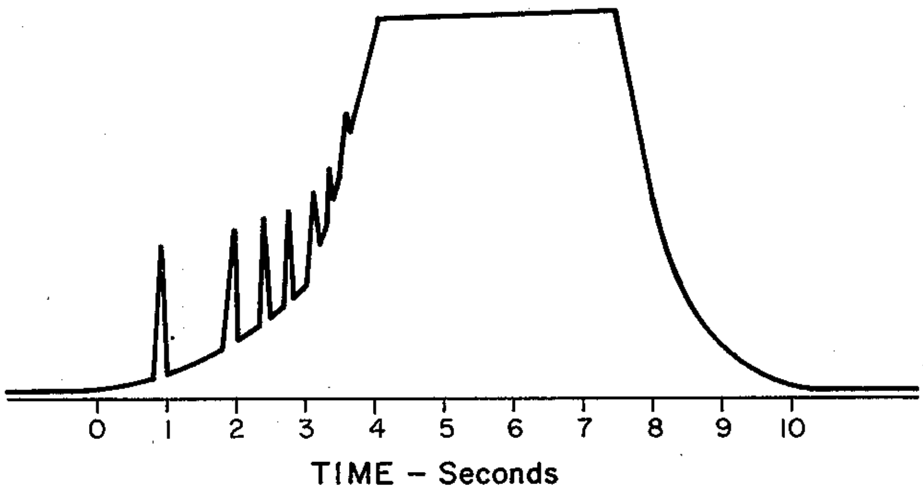

Figure 2




DISTANCE BETWEEN CARS (FEET) = D

(a) LEFT OF LINE A-A REGISTERS ONE ACTUATION ON PRESENCE SENSOR.
(b) RIGHT OF LINE A-A REGISTERS TWO ACTUATIONS ON PRESENCE SENSOR.
(c) BELOW LINE B-B REGISTERS TWO ACTUATIONS ON PULSE SENSOR.
(d) ABOVE LINE B-B REGISTERS ONE ACTUATION ON PULSE SENSOR.
(e) AREA ENCLOSED BY A-A, B-B, C-C IS AREA OF IMPROVEMENT WHERE THE PULSE SENSOR WILL REGISTER TWO ACTUATIONS BUT THE PRESENCE SENSOR WILL ONLY REGISTER ONE ACTUATION.

Figure 3




SLOW MOVING CAR

Figure 4

# APPENDIX

## Tests

One unit of the new sensor has been investigated as follows:

1. Lab Tests

   a. A distortion signal was generated by a linear variable capacitance of 230 pf, which was connected into the loop circuit and driven by a DC motor. The distortion signal observed on an oscilloscope was a triangular wave. At motor speeds below 30 rpm, 2 actuations per revolution were obtained. At speeds above 140 rpm, the unit responded only on alternate revolutions. Inductance change calibration and simulated vehicle speeds were computed from these known values.

   b. To simulate coincidence counts, two test loops were connected in parallel. Two iron plates fixed to the ends of a wooden bar were rotated across the loops by a variable speed motor. The location of the coils was adjusted to give two distortions displaced against each other in time. It was found that two pulses were obtained if the entry of the two iron plates into the respective loops was more than 0.3 to 0.4 seconds apart.

2. Low Speed Tests

   Several vehicles were driven across a loop installed in the yard of the Division of Highways at 5900 Folsom Boulevard. The distortion signal was photographed on an oscilloscope. The signals shown in Figure 1 were obtained in the presence mode of the sensor. The scale for the inductance change was computed from the magnitude of the signal generated by the 230 pf capacitor test. In the pulse mode, more than one pulse was obtained when traversing the loop very slowly (see Figure 4). Figure 4 shows also that the spacing between successive output pulses depends somewhat on the distortion signal. At the test site near Antelope Road on Interstate 80, the unit was operated with two loops in parallel. Multiple pulsing at extremely low speed was again observed.

3. High Speed Tests

   Observation of freeway traffic provided no example of coincidence losses or missing counts. The accuracy of the unit does not seem to decrease if the sensitivity of the sensor unit is decreased to a point where coincidence counts will not lead to saturation in the circuitry.